

3.1 INTRODUCTION - STORMWATER MANAGEMENT

3.1.1 These policy statements are standards and interpretations made to assist in the implementation of the requirements of the ordinance. These policies are to be followed unless adequate documentation is submitted to and approved by the City Engineer that demonstrates that the intent and requirements of the ordinance will still be met.

3.1.2 Definitions

- A. ***Adjacent Grade:*** the elevation of the ground, sidewalk, patio, deck support, or basement entryway immediately next to the structure.
- B. ***The 100-Year Flood:*** a flood with a one percent chance of being equaled or exceeded in any given year. Throughout the United States, the standard for floodplain management is protection from flooding up to and including the 100-year flood event. In hydrology the 100 year flood is determined statistically from long term records of streamflow or rainfall data. The availability of useful streamflow data for estimating the 100-year flood in most parts of Arizona is very limited. Therefore, the value is generally estimated from rainfall records. Statistical methods are used to predict the 100 year rainfall amount that is then input into hydrologic watershed models. The hydrologic model then predicts the peak rates of runoff for that amount of rainfall. This approach assumes that: the 100-year- rainfall produces a 100-year flood; weather characteristics remain constant; and the watershed and channel characteristics are correctly modeled and they remain constant.

Inherent in the statistical estimating procedure is that as additional data records become available and are added to the data base the estimated size or frequency of a specific flood can change. The often heard comment: "we have had three 100 year storms in the past two years" is statistically possible. This should be expected and is not unusual when working with a relatively short data base in the arid southwest. Rainfall and runoff events are infrequent and highly variable in the arid regions of the Southwest. Therefore, they are also more difficult to measure and predict than in the more humid regions of the Southwest and the more humid regions of country.

3.1.3 Drainage Characteristics

A. Drainage Easements:

Drainage easements should be identified as early as possible, in the planning of any development project, preferably as part of the master plan process. The City will check for and avoid discontinuous drainage easements. For a variety of reasons only a small percentage of the drainage easements needed to cover all the washes and channels in the City have been dedicated and recorded. As a result, many discontinuous drainage easements exist throughout the City. The protection and proper operation and maintenance of these wash corridors are greatly complicated by the lack of continuous and complete drainage easements along these corridors. Maintenance is generally the responsibility of the individual property owner or the Homeowners Association. The recorded plat and grading and drainage plan should specify maintenance responsibility.

3.1.4 Design Procedures and Criteria

A. Drainage Policy

City of Goodyear requires 100% retention of all on-site storm water runoff for the entire site's ultimate development for the 100 year six (6) hour storm.

B. Alluvial Fan Development Policy

1. Introduction

- a. The purpose of this policy statement is to clarify development issues and requirements on alluvial fans for subdivisions and single family homes. These areas were mapped by the Federal Emergency Management Agency (FEMA) and identified as alluvial fan AO Zones on Flood Insurance Rate Maps (FIRMs) Several other large, unmapped areas in south Goodyear are also subject to similar alluvial fan flood hazards. Because, it is essential that the special requirements in alluvial fan flood zones are clearly understood and adhered to in all development projects.
- b. Development can occur on an alluvial fan or FEMA designate AO Zone, however, development must be carefully planned, designed, and constructed in accordance with FEMA and COG regulations. This

is due to the hazards associated with: the peak discharges and volumes of water; debris and sediment; potential erosion and scour; and possible relocation of the flow paths characteristic of alluvial fan flooding.

- c. There are two primary concerns in the planning and design of any development within an alluvial fan. First is the safety and protection of the residents and property within the proposed development. Second is the potential adverse effect on adjacent and downstream residents and property owners.

2. Development Requirements

- a. The following information on the development requirements on Alluvial Fans is a summary of requirements. This summary is based on a review of the City's Floodplain and Drainage Ordinance; common drainage law; FEMA rules and regulations; and the City's Bullard Wash Open Space Project. This is not necessarily inclusive of all the requirements of applicable Federal, State or local laws or regulations. None of the following eliminates the need to comply with any laws or regulations not specifically mentioned herein. Following these requirements is also not a guarantee against flooding. Floods larger than the design flood addressed in this policy can and will occur from time to time.
- b. These are two conditions under FEMA and COG Floodplain and Drainage Ordinance regulations in which development can occur in a mapped alluvial fan flood hazard (AO) zone by meeting all FEMA requirements for a map revision. The first method is for the proposed development to remove itself entirely from the AO zone by meeting all FEMA requirements for a map revision. The second is to provide the specific flood protection measures required on alluvial fans by FEMA and COG Ordinance without revising the map and obtaining required flood insurance. The following is a summary of the requirements associated with the two conditions.

3. Removing the Project Area from the AO Zone, via a FEMA Map Revision
 - a. The only basis for a map revision on an alluvial fan acceptable to FEMA are: “major structural flood control measures”. The design and construction must be supported by sound engineering analyses that demonstrate that the measures will effectively eliminate the alluvial fan flood hazards. Revisions based on fill are not acceptable by FEMA on alluvial fans.
 - b. FEMA requires engineering analyses that quantify the discharge and volume of water, debris, and sediment associated with the 100-year flood. This must be done at the alluvial fan apex under current and potential adverse watershed conditions. It must be shown that the proposed measures will effectively eliminate alluvial fan flood hazards from the fan area.
 - c. The standard minimum FEMA freeboard requirement for flood control structures on an alluvial fan is three to four feet, depending on the proximity to bridges, etc. The City will require engineering analysis that demonstrates to FEMA’s satisfaction, that adequate protection will be provided. A lesser freeboard is possible; however, FEMA will not accept a freeboard of less than two feet.
 - d. Another FEMA requirement is that the City of Goodyear must assume ultimate responsibility for all operation and maintenance activities for the flood control measures. This could be accomplished in a variety of ways, such as utility or improvement districts, homeowner’s association or contracting to the County Flood Control District.
 - e. The proposed development must address the impact of the project on flood hazards in the flood hazard area (other areas of the fan), as well as adjacent or downstream areas.
 - f. The time required for FEMA approval can be significant, depending on the complexity of the situation.

- g. Homeowners would no longer be required to purchase flood insurance under this development option, once FEMA approved the map revision.
- 4. Development Without Removal from the AO Zone Designation:
 - a. Under this approach, homeowners are still required to buy flood insurance if they have a federally insured mortgage. They must also meet all the criteria listed below.
 - b. Proposed building sites (single family residence or subdivision) must be reasonably safe from flooding from the 100 year event.
 - c. Residential structures must have the lowest floor (including basement) elevated above the highest adjacent grade at least as high as the depth number specified in feet on FEMA's Flood Insurance Rate Map (FIRM). If no depth is specified on the FIRM a minimum of two feet above the highest adjacent grade is required.
 - d. Adequate drainage paths must be provided around structures on slopes, to guide floodwaters around and away from proposed structures. Structures should not be located in natural low areas or in wash bottoms.
 - e. The proposed development must address the impact of their project on flood hazards in the flood area (other areas of the fan), as well as on adjacent or downstream areas beyond the mapped AO Zone.
 - f. Any property below an alluvial fan apex, that has not been structurally contained, must protect its upstream perimeter with structural flood control measures. These measures must be designed to withstand the entire flow quantities at the apex, plus any intervening flows, based on current existing watershed conditions. This criterion assumes that run off from the upstream watershed will not increase in the future.
 - g. The design flow quantities for the perimeter protection may be adjusted if it can be demonstrated

by sound engineering analyses that the actual quantities that could reach the perimeter of the development are different from those at the apex. City Drainage Planning Staff must be consulted first for guidance and approval of the approach and methodology. Some general guidelines have been developed and are available from the City's Drainage planning staff.

5. Property Adjacent to one of the City's proposed Bullard Wash Open Space Project (BWOSP) channels, the Gila River or Riparian Habitats.
 - a. On property that contains any portion of one of the City's proposed BWOSP channels, the Gila River or Riparian Habitats, that develops prior to the installation of the project, the owner may be required to, as part of their development costs, dedicate the necessary Drainage Easement and construct the flood control structures that are a portion of the BWOSP, the Gila River or Riparian Habitats on their property.

C. Summary of Drainage Design Policy Guidelines
The following policy guidelines are based on recurring drainage and flooding problems observed in Goodyear related to specific design or construction practices:

1. Subdivisions
 - a. A subdivision should always have an approved subdivision-wide drainage plan. Drainage based on individual lots submitting separate grading plans as each lot is developed should be avoided.
 - b. Avoid design of a common drainage facility that requires maintenance by individual property owners. Put the drainage facility in a common Tract with the Homeowner's Association responsible for maintenance.
2. Storm Drains
 - a. Avoid if at all possible the interception of the flow in an offsite natural wash with the intent of collecting it and putting it into a pipe or an underground storm sewer system.

- b. Washes and even man-made channel carry a never ending supply of sediment and debris. It is almost impossible to collect and filter out this debris without a constant clogging and maintenance problem. If there is no alternative to the routing of an open channel into a piped system, water should be first routed into a sediment or debris basin. Periodic maintenance of the debris basin should be planned.

3. Culverts

- a. Culverts should not be placed more than 0.5 feet below the natural wash invert, or the capacity must be reduced by the cross section area below this depth.
- b. Culverts or homemade bridges for private driveways or walkways over washes or drainage channels whose source originates off-site or off-lot should be designed by a professional drainage designer.
- c. Small drainage structures not designed with any hydrologic and hydraulic analysis may be OK for crossing channels originating onsite (on-lot). However, homemade drainage structures can be disastrous for the homeowner, his neighbors, and adjacent streets if installed on larger washes originating offsite (off-lot), therefore in this situation, dip crossings or free span bridges which don't constrict channel flow capacity are recommended.

4. Open Channels

- a. Diversions of natural washes or changes in the channel's profile should be avoided whenever possible.
- b. Do not permit encroachment into a drainage easement, channel, or its floodway.
- c. If channel lining or landscaping material is used it must be inlaid or located below the design invert (bottom) or the channel. Do not place it on top of the designed finished grade of the channel cross

section. The channel surface material (roughness coefficient) or cross sectional area shall be changed without a plan revision and reapproval by City Staff.

This is a serious wide-spread construction and design oversight. Lining and landscaping material is commonly and incorrectly shown on plans and actually placed on top of the design channel bottom. This reduces and can eliminate a channel's conveyance capacity. This practice also makes it difficult for flow to enter such a channel, often causing ponding and backwater problems on streets and adjacent properties.

- d. If only the channel banks are being lined, the lining material must extend down below the channel invert to below the anticipated scour depth.
- e. Avoid designing turns in open channel conveyance systems sharper than 45 degrees, whenever possible. If curves or bends can't be avoided the run-up on the outside of curves must be calculated and incorporated into the channel design.
- f. Lot lines should not extend out where they overlay or cross a drainage easement or wash. The wash area or drainage channel should be dedicated in a separate drainage easement Tract whenever possible. This will avoid "backyard to backyard" drainage channels, which can result in serious flooding problems.
- g. Block walls or fences commonly separate lots. Channels that go under or through these walls commonly catch debris, clog, and block or divert flow. Homeowners will sometimes unknowingly and other times on purpose block off or plug these openings. There is no way for the City or a Homeowner's Association to inspect, or maintain these openings. In addition, the size of many of these openings is never actually designed or analyzed. Backyards, pools, houses, and lots can be flooded; and walls knocked over and/or undermined when these openings do not function properly.

These situations should be avoided where ever possible.

- h. Lot lines should end at the edge of the wash floodplain, or man-made channel, not in the middle or on the other side. Building envelopes are not recommended for delineating drainage easements. They can help but are too often misunderstood or ignored as a limit to construction of walls or structures.

5. Drainage Easements

- a. Acquire all required drainage easements as early in the planning and development process as possible. Do not allow discontinuous drainage easements. Fill in missing Drainage Easement segments in in-fill areas as development takes place.

6. Stormwater Detention or Retention

- a. Offsite runoff should not be routed into or through onsite subdivision stormwater storage basins.
- b. Basins located on-stream interrupt the natural flow regime of the wash and can: create a continual debris and sediment maintenance problem for the property owner; affect the ability of the basin to drain within the required 36 hours; and if storage is above ground a flood hazard is created for downstream residents.
- c. Storage basins should be designed if at all possible with a gravity drain system and not rely on pumps.
- d. Above ground storage basins contained by fill, levee or berm, should be avoid whenever possible.

- e. On-lot retention on single family residential lots is not permitted.

These are traditionally filled in by homeowners within several years in the process of landscaping. Runoff then ends up in their house, pool, on their neighbor's property, or in a City alley or street.

3.1.5 Stormwater Storage Facilities

A. Stormwater Storage Policy

“As a minimum, all development will make provisions to store runoff from rainfall events up to and including the one-hundred-year six hour duration event.”

1. The storage requirement applies to the “development”. The development refers to the area within the entire development site. The volume of storage provided onsite must equal the total runoff volume generated from all the areas within the entire site for fully developed conditions. Pre-development versus post development comparisons are not applicable in computing required storage volumes.
2. This policy statement and clarification does not change any requirements or criteria contained in the City Ordinance.

B. Drainage of Stormwater Storage Facilities

See section 3.3 of this manual.

3.1.6 Requirements for Certifications and Required Permits

A. Wall Permits

It is COG policy that requests for wall permits crossing a wash or drainage easement shall be approved by the Public Works Director, or his designee. Walls will be evaluated in relationship to the location of natural washes and the proposed drainage plan for the site as well as for compatibility with adjacent natural and manmade drainage facilities.

B. Stormwater Storage Volume Certification:

The property owner will provide the City with certified as-built dimensions of the basins and the actual volume of storage provided. This must be based on “as built” topographic surveys made by either a civil engineer or land surveyor who is registered to practice in the state of Arizona. These as-built volumes must reflect permanent finished landscaping in place. The volumes shall be certified by the Designed Engineer that the volume

provided meets or exceeds the required design volumes per COG Ordinance and the approved Drainage Report. The volume of storage provided must equal or exceed the approved design volumes before the City will issue Letters of Acceptance.

3.1.7 Obstruction of Waterways Prohibited

A. Obstructions in Drainage Easements

It is the policy of the COG that drainage easements be maintained in an open condition, free from obstructions, in order to pass the flows up to and including the 100-year event. Walls, fences, pools, landscaping, and other permanent structures should not be located in drainage easements. Even if indemnified agreements are obtained, once these types of improvements are installed, it is extremely difficult to remove such improvements. They become an obstruction to flow which can result in damage to others, as well as being damaged themselves .

3.1.8 Stormwater Storage Requirements Waiver Policy

- A. Under the current City of Goodyear policy, stormwater storage is required for 100% of the 100 year storm, requirements may be waived if a project meets one or more of the specified criteria listed below. If the project meets the waiver criteria the City has the option, if it is in the best interest of the public, to grant the waiver. Meeting the waiver criteria, however, does not mean a waiver is automatically granted. Granting or denial of the waiver will only be given after formal review and processing by City staff.
- B. If a waiver is granted, Ordinance No. 94-497 requires controls to reduce pollutants for the 100 year storm or any amount leaving the property.
- C. It is not appropriate to automatically assume stormwater retention is not required because a project area is small relative to the entire watershed.
- D. To obtain a waiver, the developer or their engineer must submit a Request for Retention Waiver Review form and six (6) Preliminary Drainage Reports to the City. After City review, upon approval or denial, the applicant will receive a copy of the completed request form and the Retention Waiver Review form. A waiver approval (the completed Retention Waiver Review Form) must be obtained prior to the processing of any proposed development plans.
- E. If a waiver is granted:

1. All onsite storage requirements are not automatically eliminated. If the project can drain directly into an existing regional drainage system designed and constructed to contain or convey the additional runoff, storage requirements may be waived. If not, the development must store the runoff volume necessary to maintain the integrity of the drainage system.
2. Authorization is not granted by the City for the developer to increase runoff or change drainage characteristics to the detriment of any other property owner.
3. The developer is not relieved of liability if the development causes increased drainage problems or flooding on any other property.

3.2 HYDROLOGY AND DRAINAGE REPORT PREPARATION

3.2.1 Introduction

A. General Comments

1. This manual section describes the City's policies concerning hydrologic analysis procedures to be used in the City of Goodyear for the planning and design of drainage and flood control facilities and the preparation of accompanying drainage reports. This manual contains recommended procedures, equations, data and basic assumptions which the planner or designer is generally required to use. If a situation is encountered in which the use of other methods or data in addition to or instead of these are believed to be more appropriate, then City Drainage Planning staff should be consulted and advance approval must be received before using them. When methods or data not described in this booklet are used, the drainage report must include enough information to enable the City Staff to fully evaluate the applicability of the methods and data.

- a. **Basis of Design**
The Drainage Design Manual for Maricopa County; Volume I, Hydrology, shall be used to determine peak discharges and volumes for design purposes. For flood control projects that are cost-shared with the Flood Control District of Maricopa County, the hydrologic design procedure contained in Vol I, Hydrology of the Drainage Design Manual for Maricopa County must be used.

Peak flow rates shall be determined by the following two methods, as applicable: the Rational Method and rainfall-runoff modeling using the U.S. Army Corps of Engineers' HEC-1 Flood Hydrograph Package.

- (1) The Rational Method is acceptable for small, uniform, regularly shaped watersheds less than 160 acres.
- (2) The Corps of Engineers' HEC-1 computer modeling is required for small watersheds that are non-uniform, irregular in shape, when

routing of flows are necessary, or for areas larger than 160 acres.

2. Study Requirements

A hydrology study shall be performed for each development within the City. The study shall define the overall and sub-drainage areas. It shall also determine appropriate hydrologic data for the following:

- a. Off-Project Areas - The peak flows, times of concentration, and other hydrologic data, for each off-project drainage area tributary to the project shall be computed and submitted in summary form.
- b. Project - Sub-Basins - The project shall be divided into sub-basins tributary to appropriate design points. The pertinent hydrologic data shall be computed for each and submitted in summary form.
- c. "Appropriate Design Points" are those points wherein the peak flow rates, or other pertinent data, is needed to determine flow capacity requirements, inflow-outflow relationships, etc. These "points" would include, but not necessarily be limited to, the following: inflow-outflow points of retention/detention basins, up and/or downstreams ends of culverts; intake points for storm drains (i.e. inlets, catch basins, scuppers, etc.); points immediately upstream and downstream of channel junctions and/or street intersections; others as may be necessary to give a complete hydrologic picture and allow a thorough hydraulic evaluation and/or design of the drainage system:

B. Goals and Objectives

The following are the basic goals and objectives used as guide in preparing this manual:

1. Reflect current requirements of the City ordinance, as well as other applicable County, State or Federal regulations.
2. Use the best and most current data and methods available.

3. Provide guidance for hydrologic design methods that:
 - a. reflect commonly accepted state of the art procedures;
 - b. produce safe, reasonable results (within an acceptable range of values);
 - c. gives flexibility to the designer while at the same time maintains a reasonable level of design consistency in order to facilitate design review;
 - d. are not unnecessarily complex or confusing;
 - e. does not require more detailed or complex input data than is commonly available;
 - f. are technically and legally defensible;
 - g. provides results that are consistent with adjacent jurisdictions, primarily the Flood Control District of Maricopa County (FCDMC) and ADOT.
4. Because of our efforts to meet the above goals and objectives, some options in this manual differ slightly from adjacent jurisdictions, such as the Flood Control District of Maricopa County. However, results do not differ significantly.

C. Application and Limitations

1. The purpose of this manual is to provide a means of assisting in the prediction of runoff which might result from a design storm of a given return interval.
2. Hydrology is a discipline which requires not only technical competence but also experience and good judgment. The City does not warrant or guarantee the reliability of the hydrologic methods, techniques, and/or parameter values described herein. The user of this, manual is thus expected to validate the reasonableness of the predicted values by: applying alternative methods or other appropriate checks which have been developed for this area. Failure to do so may result in erroneous values.

3. It is not the intent nor purpose of this manual to inhibit sound innovative design or the use of new techniques. Therefore as mentioned previously, where special conditions or needs exist, other methods and procedures may be used with prior approval.
4. It is anticipated that, over time, as more data becomes available and/or more appropriate techniques are developed, this manual will be revised. Such revisions will probably take place annually or as needed. If any inadequacies or inaccuracies are found with any of these procedures, they should be brought to the City's attention immediately.

3.2.2 Drainage Report Preparation

A. Requirements for a Drainage Report

1. A drainage report is required by the City to document the effect that a proposed project would have upon stormwater runoff in the vicinity of the project; to provide data supporting the design of facilities to be constructed for the management of stormwater runoff. Each drainage report must consider runoff from storms with a return frequency up to and including a 100-year storm. The complexity of the report depends upon the nature of the project and the site on which the project will occur.
2. A drainage report shall be submitted by a professional Civil Engineer registered in the State of Arizona requesting one of the following:
 - a. Approval of a subdivision plat (preliminary and final)
 - b. A permit for grading
 - c. A permit to construct right-of-way improvements
 - d. A permit to construct any structure

B. The purpose of a Drainage Report

The purpose a drainage report is to document that stormwater runoff has been considered in the planning of each project and the public and its property will be protected from damage by runoff flows and flooding. The requirement for this protection not only applies to those who will own and/or use a proposed project but

also to those who own or occupy property adjacent to or near the proposed project.

3.2.3 Six Elements of a Drainage Report

A. There are six elements of a drainage report which normally must be present to demonstrate that the effects of storm water runoff have been considered and that the runoff will be properly managed by the project. Subparagraphs 1,2,3 and 6, below, are elements found in “Preliminary Drainage Reports” or “Master Drainage Reports;” and subparagraphs 4 and 5, below, should be added to Final Drainage Reports to support design choices shown on construction plans. There will, of course, be cases when one or more of these elements would not be applicable, and there could be special projects requiring analysis or information not covered in these six elements. The six elements are described in the following subparagraphs. In addition refer to the Drainage Report Outline Checklist for specific items that might be included within a drainage report and Master Drainage Plan Requirements.

1. Description of the Property and the Watersheds:
Each drainage report must have a section which includes a narrative, and topographic maps that describes the location and condition of the property the project is located on (on-site conditions) and the upstream (off-site) watersheds as well as any downstream constraints which affect the property.
 - a. On-site Conditions: An essential part of each report is a topographic map which shows the location of the project area.
 - (1) Description of existing drainage patterns including natural and man-made channels and watershed boundaries on the property.
 - (2) Mapping of the 100 year floodplain for washes with a capacity of 100 cfs or greater.
 - (3) Description of the existing ground cover conditions and the identification of the SCS hydrologic soil group(s) found on the property.
 - (4) Description of how existing development located on the property affects drainage.

- (5) Description of how existing and/or proposed developments on adjacent properties affect drainage on the project area.
- b. Off-site Watershed Conditions: Watersheds above the project area from which stormwater runoff enters or affects the project's property must be delineated on topographic maps. These maps should be prepared at a scale which will clearly show the drainage areas so that the watershed boundaries can be drawn with accuracy. Contour lines should be shown on the maps at an interval appropriate to the ground slope and complexity of the terrain.
- c. The narrative description should include the following things:
 - (1) Existing upstream and downstream drainage patterns on the watersheds.
 - (2) The natural ground cover and the SCS hydrologic soil group(s) found on the watersheds.
 - (3) Existing development on the watersheds and how this affects drainage.
 - (4) The location and type of development that would exist on the watersheds
 - (5) Any condition which would significantly affect the way the runoff from the watershed would be analyzed.
2. Estimation of Stormwater Runoff:

The report must provide estimates for selected storm return frequencies of peak stormwater runoff rates at concentration points entering and leaving the property , onsite, from off-site watershed areas. In addition, the report must include estimates of stormwater runoff volumes from the project area or development site that are required to be stored on-site in accordance with City Ordinance requirement.

3. Evaluation of the Effects of The Project:
 - a. The report must show how stormwater runoff will be handled when the project has been completed and how the project will affect stormwater runoff.
 - b. Depicting Pre- and Post-Project Topography: Prior to the project of development of a piece of property, topographic conditions existing on the property which will influence and direct the flow of drainage water which enters the property from watersheds above it or which originates on the property. When the project has been completed, certain topographic changes will have occurred which influence the drainage flows and resulting time of concentration. It is necessary that the drainage report include sufficient pre- and post-project topographic information to demonstrate the effects of the project. This information should be depicted on contour maps. In addition to showing the developer's property, these maps should also show enough of the adjacent property to give a clear picture of what exists, what will affect drainage, and what will be affected by drainage on the property being developed. Information about adjacent property, such as significant differences in elevation, walls, drainage structures, buildings with their floor elevations, etc. must be included.
 - c. Pre- and Post-Project Stormwater Runoff of Offsite Flows: The amount and type of stormwater runoff that would exit the property prior to the project and after the project must be depicted for a 5-year, a 10-year, a 50-year and a 100-year storm. If, as a result of the project, drainage flows will be reduced by facilities such as retention or detention basins, the effect of these facilities on flows exiting the property should be described and depicted on appropriate maps.
4. Presentation of the Basis for Design of Facilities to Manage Runoff:

This presentation includes a summary of the design criteria used, a brief description of the design approach and methods used. The sketches, data, and calculations which support the selection of materials, the locations, and design

of facilities should be included. (See Section 3.1 for design criteria and policy guidance and Section 3.3, Hydraulics, for design guidance of the specific drainage facility.)

5. Presentation of the Basis for Selecting Elevations for the Lowest Floor:
Elevations must be selected to provide protection from flooding. The basis for the selection of a floor elevation or the design of protection for the interior of the building must be presented. (See Manual Sections 3.1 and 3.3)

6. Description of the Provisions for Project Phasing:
 - a. Any project, particularly a large one, may have stormwater runoff, flooding, and erosion problems during the construction phases which would not exist after the project has been completed. The report must indicate how the phasing will occur, what interim drainage problems are anticipated, and what must be done to alleviate these problems..
 - b. As of October 1, 1992, the National Pollutant Discharge Elimination System (NPDES) General Permit for stormwater discharges requires all owners/operators of construction projects disturbing five or more acres to prepare a Storm Water Pollution Prevention Plan (SWAPPP) and file a Notice of Intent (NOI). The NOI must be sent to the United States Environmental Protection Agency.

The city must have evidence of this permit. A copy of the NOI must be present on the job site at all times.

The goal of this NPDES storm water permit for construction activities is to reduce erosion potential, minimize sedimentation, and to eliminate non-stormwater discharges for construction sites.

3.3 HYDRAULICS

3.3.1 Introduction

- A. The design of drainage and flood control facilities in the City of Goodyear shall follow the current Drainage Design Manual of the Flood Control District of Maricopa County (FCDMC), Volume II, Hydraulics, as supplemented by this manual section. This manual contains clarifications or modifications applicable to the design of facilities within the City of Goodyear (C.O.G.).
- B. Hydrology
The determination of flood hydrology for designing stormwater facilities in the City of Goodyear shall be performed according to the procedures set forth in the City Design Standard Manual. Table 3.3-1 outlines the minimum hydrology design criteria for storm water management and drainage facilities within the City of Goodyear.

3.3.2 General Information

- A. All developments within the City shall provide such storm drainage facilities as are necessary to insure that all structures and properties, both within the development and those located up and downstream of the development, shall be protected from the adverse impact of stormwaters due to the proposed development.
- B. All on-site drainage channels and other structures handling stormwater runoff shall be designed and constructed in accordance with these standards, including single family residential lots. Any proposed structural changes which may accelerate, retard, convey, or redirect surface water runoff in any way must be approved by the City Engineer.
 - 1. Any culverts installed for storm water conveyance shall be 18 inches minimum inside diameter, constructed of approved materials.
 - 2. All culverts shall be installed with both upstream and downstream end sections or headwalls of appropriate type from MAG Standard Details.
 - 3. Where driveways cross existing stormwater channels, the finished elevation of the driveway at the point of crossing the channel shall be at or below the lowest top of curb elevation at the intersection of the driveway and the public street. Where the flow line of the channel is less than 2 feet below the lowest

intersected curb elevation a drop inlet type headwall shall be required if a culvert is used.

- C. The City's storm drainage system shall be developed within two broad classifications as follows:
1. The "MINOR SYSTEM" (10 year) shall consists of those collection and/or retention/detention facilities necessary to collect, convey, retain and/or detain stormwater runoff from the more frequent rainfalls. (This is generally considered as the "formal" drainage system). The "Minor System" shall be designed to accommodate storms up to and including a "ten year storm".
 2. The "MAJOR SYSTEM" (100 year) shall consist of those facilities necessary to convey stormwater runoff from storms up to and including a "one-hundred year storm". The design of the "Major System" is somewhat less formal than that of the "Minor System". It consists primarily of the planning and / or analysis of the overall drainage system to insure: that there is always positive drainage from all areas, volume retention is available and that the "one-hundred year" offsite flows can safely pass through the project.

3.3.3 Drainage Facilities Shall Consist of The Following Components:

- A. Collection System
This portion of the system is intended to collect and convey runoff to either retention/detention facilities and/or outfall points. In general this system consists of the following:
1. Surface Drainage Facilities
 - a. Streets
 - b. Open channels
 - (1) natural
 - (2) manmade
 - ◆ grass lined
 - ◆ gunite/concrete (i.e. smooth lined)
 - ◆ rip-rap

2. Sub-surface Drainage Facilities
Sub-surface drainage facilities are required whenever the capacity of the surface system is exceeded. It is comprised of the following:
 - a. Pipes (plastic and cast-in-place not allowed in public system)
 - b. Manholes/junction boxes
 - c. Catch basin and inlets
3. Retention/Detention Facilities
This portion of the system is intended to retain/detain sufficient volumes of runoff to minimize the adverse impact of the new developments on downstream areas.
 - a. All developments must provide retention/detention facilities.
 - b. Single-Family development, when the lots are less than one acre in area, shall provide a common retention tract that is maintained by the Homeowner's Association.

On-lot retention on individual single family residential lots is not permitted as a solution to subdivision retention requirements, unless lot sizes are one (1) acre or greater.

3.3.4 Drainage

A. Street Drainage

1. Streets shall be designed to carry the following minimum flows:
 - a. Arterial to carry ten year flow between the curbs, the fifty year flows between the property lines.
 - b. Collectors and local streets to carry five year flows between the curbs, the fifty year flows between the buildings (front yard and street).
2. Underground storm drains or open channels are required when the street capacity is exceeded.

3. Dip crossings of open channels shall only be accepted when an alternative all weather access is available to every property. When dip crossings are allowed they shall comply with Table 3.3.1.
4. All storm drains and channels shall be constructed in public rights-of-way or dedicated easements.
5. Pavement Encroachment
Typical street sections used in City of Goodyear are in City of Goodyear Supplement to Maricopa Association of Governments Uniform Standard Details for Public Works Construction.
6. Theoretical Capacity
A Manning's "n" value of 0.020 for residential streets and parking lots and 0.016 for non-residential street flow unless special conditions exist which then must be clearly documented in the Drainage Design Report.
7. Longitudinal Street Grades
 - a. The desirable minimum longitudinal street grade is 0.4% to ensure good gutter drainage. Wherever possible, longitudinal street grades greater than or equal to the desirable minimum grade shall be provided. It is recognized that this desirable grade is not always attainable, particularly with projects involving existing streets. Therefore, the absolute minimum longitudinal street grade is 0.15%.
8. Design Criteria for Intersections
 - a. Valley gutters shall be used to transport runoff across local streets when a storm drain system is not required. However, valley gutters are generally not acceptable for collector or arterial streets.
 - b. In unusual cases, valley gutters may be required to cross collector streets in which case a wider eight foot design width should be used. Mid-block valley gutters should be avoided.

9. Design Criteria for Roadside Ditches

- a. Geometry
Geometry shall be designed to allow maximum conveyance of flows and minimal maintenance.

10. Catch Basins

- a. Catch Basins shall be City of Goodyear, Type "M".
- b. SCUPPERS: MAG Standard Detail 206 shall be used as basis of scupper design unless prior approval of another design is obtained from City Public Works Director, or his designee.

B. Drainage Between Lots

- 1. No subsurface routing of drainage ways between lots or buildings shall be permitted in an easement unless the Public Works Department has approved in writing the placement of the drainage way(s) in an easement(s) and the property owner has granted the necessary easement(s) and right(s)-of-way.
- 2. If approved, the channel shall be designed to convey the one hundred year flow without flooding adjacent properties.
- 3. If approved, the channel shall be constructed in a dedicated drainage right-of-way leading to a positive outfall point. The minimum width of the right-of-way shall be the top width of the channel plus eight feet for a maintenance roadway. The ends of the right-of-way shall be treated in such a manner as to prevent non-maintenance vehicular access without diminishing the hydraulic capacity of the channel. A minimum of 25% of the up-stream opening shall be assumed to be clogged with debris.
- 4. Underground drainage structures shall not be accepted.

C. Underground Storm Drains

- 1. Underground storm drains shall be provided whenever the capacity of the streets is exceeded.
- 2. Pipes shall be sized using "Manning's Formula". Values of Manning's "n" shall be per appropriate technical literature and shall be referenced.

3. Velocities shall range from 3 fps to 9 fps.
4. The minimum pipe size of the lateral collector shall be 18" ID, and the minimum pipe size of the main is 24" ID. In situations where debris is expected, the City's Public Works and Engineering staff should be consulted for applicable debris criteria.
5. The hydraulic grade line may be above the pipe, provided that it remains at least one foot below the ground elevation at all manholes, catch basins, inlets, etc.
6. When the pipe changes direction more than 30 degrees there shall be a drop, between match points, of at least 0.1 feet. In no case shall the deflection angle be greater than 90 degrees.
7. Separation of Storm Drain from Water and Sewer Lines
 - a. Horizontal separation of storm drains and water or sewer lines shall be a minimum of 6 feet.
 - b. Vertical separation of storm drains and sewers should be 2 feet (sewer below) unless the sewer line is manufactured from ductile iron with mechanical joints or equal.
 - c. Vertical separation of storm drain and water line (water line below) shall be 2 feet clear.
 - d. Separation is measured from the outside of the two pipes.

3.3.5 Drainage Materials

A. Pipes

1. Standard material for storm drain pipes in the public rights-of-way shall be rubber gasket, reinforced concrete pipe (R.G.R.C.P.) per ASTM C76. Generally the minimum rating shall be Class III. When the cover is less than two feet the minimum rating shall be Class IV, or concrete backfill used subject to City approval.

B. Manholes/Junction Boxes

1. Materials - all manholes shall be MAG Standards, Details and Specifications.

2. Locations - manholes and/or junction boxes are required at all of the following:
 - a. Junctions of two or more pipes
 - b. Changes in grade
 - c. Changes in alignment
 - d. Changes in pipe sizes (pipe crowns to match)
3. Spacing - the maximum spacing for manholes shall be:
 - a. 400 feet on lines 18" to 36" diameter
 - b. 660 feet on lines 36" in diameter

C. Open Channels

1. Natural Channels - Whenever possible and appropriate it is the City's preference that existing natural drainage channels be left in a natural state. When this is the case a drainage easement or right-of-way shall be dedicated over the 100 year flood plain of the natural drainage way.
2. Man-made Channels - When man-made channels are required the emphasis would be placed on a "natural" appearance. Grass lining with side slopes 6:1 or flatter are preferred.
3. Maximum Velocities/Erosion Protection - In general the maximum velocity shall not exceed the scouring velocity of the soil (with natural cover). When the scour velocity is exceeded additional erosion protection shall be provided. The protection may consist of one or more of the following:
 - a. Concrete/gunite lining (reinforced with 4 x 4 WWF - 12GA).
 - b. Natural stone grouted rip-rap 4" to 12" diameter stones - leave a minimum 1/4 diameter exposed. Maximum 1/2 diameter exposed.
 - c. Check dams, at 3 foot elevation intervals.

4. Maintenance

- a. Access: Open channels to be properly maintained should provide reasonable access for maintenance. Minimum width of access should be 8 feet. Spacing between vehicular access points should be a maximum of 1/2 mile. A minimum of one access point per subdivision is required. Non-vehicular access points shall be provided every 660 foot maximum. If the facility is to be City maintained the above minimum requirements are mandatory.
- b. Responsible Party: Maintenance of drainage facilities within the City of Goodyear is usually the responsibility of the property owner or the Subdivision's Homeowners Association. Specific maintenance responsibilities should be called out on the Recorded Plat and the Grading and Drainage Plan.

3.3.6 Culverts and Bridges

A. Inverted Siphons

- a. General
Inverted siphons shall be used only when no other solution is available to the designer. Prior City Engineer approval is required.

3.3.7 Detention or Retention Facilities

A. Sizing

1. Basis of Design

- a. All retention/detention facilities shall be sized to retain 100% of the one hundred year - six hour storm falling over the entire project (gross area including streets). For purpose of determining the volume required, the project shall be considered to extend to the centerline of all existing and/or future streets on the exterior boundaries and to include all interior streets and other rights-of-way within the project.

b. Freeboard

- (1) There shall be a minimum of one foot freeboard from the water surface elevation to the lowest building elevation and/or the gutter of the upstream streets.
- (2) There shall be a minimum six (6) inches freeboard from the water surface outfall to the lowest top of bank.

2. Volume - The following data, as applicable, shall be provided for each retention/detention basin.

a. Two methods are defined for the determination of peak flow rates: the Rational Method, and rainfall-runoff modeling using the U.S. Army Corps of Engineers' HEC-1 Flood Hydrograph Package.

- (1) The Rational Method is acceptable for small, uniform, regularly shaped watersheds less than 160 acres.

$$V = C\left(\frac{P}{12}\right)A$$

where

V = total runoff in cubic feet.

C = a coefficient relating the runoff to rainfall

P = 3 inches (100 yr. 6 hr. depth)

A = drainage area (square feet).

Drainage Design Manual, Volume I, Section 3
Rational Equation.

- (2) The Corps of Engineers' HEC-1 computer modeling is required for small watersheds that are non-uniform, irregular in shape, when routing of flows are necessary, or for areas larger than 160 acres.

3. Retention/Detention Basins shall be located such that they can intercept the flows from the entire site.

If the basin is located other than at the lowest point of the project, the Design Engineers shall denote on the master

drainage map the actual or effective drainage area. If portions of the project cannot drain to the primary basin, additional basins shall be added to retain runoff from these areas. Credit will not be given for providing volume in excess of that needed to retain the one hundred year - six hour storm from a basin's effective drainage area.

- B. Volume Certification: The property owner will provide the City with certified as-built dimensions of the basins and the actual volume of storage provided. This must be based on "As-Built" topographic surveys made by either a civil engineer or land surveyor who is registered to practice in the State of Arizona. These as-built volumes must reflect permanent finished landscaping in place. The volumes shall be certified by the Design Engineer that the volumes provided meets or exceeds the required design volumes per COG Ordinance and the approved Drainage Plan. The volume of storage provided must equal or exceed the approved design volumes before the City will issue Letters of Acceptance for maintenance of any public facilities.

C. Grading

1. Depths

- a. The basins shall not exceed 1.5 feet of water depth within 10 feet of the right-of-way unless there is a fence or other similar protection to restrict access to the area.
- b. The overall average depth shall not exceed three (3) feet without authorization of the City. If granted, the basin must be fenced to prohibit access or a side slope of 8:1 shall be provided for a minimum distance of 25 feet measured from the one hundred year high water level.
- c. While it is the City's intent that the "average" depth not exceed three feet, it is also the City's intent that the basins be contoured to present an aesthetically pleasing appearance. Therefore, up to 25% of the bottom area may be up to four (4) feet deep.
- d. In no case shall the depth exceed 1.0 foot without a positive means of disposing of accumulated runoff.

2. Slopes - Side and Bottom

- a. Bottom - The bottom of all basins shall be sloped towards the discharge points. The minimum bottom slope shall be 1/2%.
- b. Side Slopes
 - (1) Side slopes adjacent to public rights-of-way, or when there is pedestrian type access to that portion of the basin, shall have a side slope of 6:1 or flatter.
 - (2) Side slopes adjacent to walls, fences, hedges, etc. (i.e., no or limited pedestrian type access in that area) may have side slopes up to 4:1.
 - (3) Retaining walls (i.e., vertical slopes) may be used in areas adjacent to permanent walls, fences, etc.

3. Grading/Landscaping/Joint Use As Parks

- a. It is the intent of the City that retention/detention basins present an aesthetically pleasing appearance. The Design Engineer shall endeavor to "contour" the sides and bottoms of the basins to enhance appearance through varied slopes.

The developer and designer shall work with representatives of the City's Community Development Department to determine the need/desirability and feasibility of joint usage of the basin as a park site. If appropriate, the design shall provide for appropriate open areas for the recreational facilities.

- b. It is not the intent of these guidelines to dictate the specific details of the configuration to the designers however, the following concepts will be used as the basis of reviewing the plans:
 - (1) Curvilinear sides should be used in lieu of long stretches of straight lines.

- (2) Side slopes should be varied (i.e., start with 6:1 then change to 7-8:1 or more. With appropriate use of landscaping, side slopes can even be reduced to 4:1.
 - (3) Bottom areas should contour to varying depths in lieu of uniform depth/slope.
 - c. The tops and bottoms of side slopes shall be rounded off - generally over a distance five of (5) feet each way of the "PI".
 - d. Landscaping - Section 7.5 defines the basic landscaping requirements for retention/detention basins. As with the grading the landscape plans shall be reviewed in regard to aesthetic effect of the proposed design.
- 4. Retention/Detention in Parking Lots.
 - a. Retention/detention in parking lots of multi-family developments is not allowed. All retention/detention of such developments shall be in landscaped areas.
 - b. Retention/detention of runoff in parking lots of industrial/commercial developments is allowed subject to the following guidelines:
 - (1) No more than 50% of the required storage volume may be retained/detained in parking areas. The balance shall be provided in landscaped areas. The tributary areas to each "basin" shall be noted on the master drainage map.
 - (2) No more than 50% of the required parking spaces shall be covered by stormwater retention/detention.
 - (3) Storage system shall be designed to store the first 30% of the required runoff volume off paved areas (to avoid nuisance water constantly ponding on the pavement).

- (4) Depth of water shall not exceed six inches within the parking area, nor shall it exceed 0.15 feet at the midpoint of any parking space.
 - (5) Interference with pedestrian traffic will be minimized in the design of the storage facility.
 - (6) A continuous fire access lane shall be provided throughout the development, and it shall be free of ponded water from the retention areas.
 - (7) All parking spaces shall be accessible during periods when the basins are filled to capacity, without pedestrians having to cross ponded water deeper than 0.15 feet.
- c. Before final plan approval an approved Drainage Report must show the calculated stormwater storage volume based on runoff from the 100 year 6-hour storm.

5. Overflow/Outfall

- a. Outfall - Each project shall be designed such that the "ultimate" outfall for all drainage in excess of the one hundred year - six hour storm is routed to a public street, storm drain, drainage channel or natural watercourse. The outfall shall be accessible without draining over private property.
- b. If such an outfall does not exist the project must provide an outfall.

6. Overflow/Conveyance

- a. Off-project flows which historically flowed through the project may be routed through the project.

Offsite runoff volumes shall not be allowed across private lots, streets, or public/private access ways.
- b. Runoff volumes in excess of those required to be retained/detained (currently the one hundred year - six hour storm) may be routed directly through the outfall, although they must be routed via the retention/detention facilities.

7. Location/Conflicts With Existing Utilities
 - a. Retention/detention facilities shall not encroach into existing easements for private utilities without written approval of the encroachment from all utilities using the easement.
 - b. Retention/detention facilities shall not encroach into public rights-of-way nor into public easements. If necessary the developer shall relocate conflicting utilities into a new dedicated easement.
 - c. The top of the retention/detention facilities (i.e., freeboard elevation) shall be at least four (4) horizontal feet from any building or public roadway.
 - d. Retention/detention facilities shall not be located within 20 feet of an active septic system nor within 100 feet of an active water well.
 - e. A minimum three feet of cover (from the bottom of the basin to the top of the pipe) shall be maintained over water and sewer service lines.
8. Disposal/Discharge
 - a. All retention/detention facilities shall have a positive method of disposing of retained/detained runoff waters. All water so retained/detained shall be disposed of within 36 hours. Public streets are not considered an acceptable outlet for disposal of retained/detained runoff, however, are considered an acceptable outlet for overflow. Only under special circumstances with prior city staff approval should pump disposal methods be used.
 - b. The minimum allowable pipe size for primary outlet structures is 18 inches.

- c. Acceptable methods of disposal of accumulated storm water runoff are:
- (1) Positive gravity outlet
- ◆ Surface percolation, evaporation, and transpiration. Drywells are not an acceptable method of disposal of accumulated storm water.
 - ◆ Discharge to an existing storm drain with a maximum discharge of one cubic foot per second. (Waiver Required)
 - ◆ Discharge to a drainage channel either natural or man-made of sufficient capacity to convey the anticipated flows from the tributary drainage area. (Waiver Required)
 - ◆ Water cannot be discharged into a city: street, gutter, or alley.
- (2) Pump Station (Waiver Required)
- ◆ to an open channel either natural or man-made
 - ◆ or subsurface directly to a nearby storm sewer system with a maximum discharge of one cubic foot per second.
 - ◆ or surface to a storm sewer system if pumped water can be discharged directly into a catch basin or other inlet.
 - ◆ Water cannot be discharged into a city: street, gutter, or alley.
- d. Basin Floors
- (1) The basin floor to infiltrate properly must be an “Engineered Basin Floor”. They are

generally landscaped and maintained for looks only.

- (2) DRAIN TIME: All storage facilities should be designed such that the stored runoff shall be discharged completely from the facility within 36 hours following the storm event. This is a City Ordinance requirement related to County Health Department Standards.

Percolation tests and results shall accompany all Drainage Reports.

9. Stormwater Storage Requirements Waiver Policy
See Section 3.1.8.
10. Nuisance Water - each basin, particularly those used as a park, shall be graded such that there is one-or-more "sump" areas wherein runoff from the more "frequent" storms and nuisance runoff may be retained/detained without flooding the balance of the basin, with preference to surface percolation.

D. Embankment Design Criteria

1. Detention or Retention facilities should be constructed below the natural ground surface.
2. The use of embankments to impound stormwater runoff requires prior approval by City Public Works Director, or his designee. Embankments become small dams that can be a serious potential downstream flood hazard.
3. If approval is obtained, all the design requirements contained in the FCDMC Manual Sec. 8.3.3 must be completely and thoroughly followed.
4. The owner/developer must provide the City as-built certification by a registered Geotechnical or Civil Engineer, experienced in dam technology, that the embankment was designed, and constructed properly, is stable, and will safely impound the design volumes of water.

E. Operation and Maintenance

Maintenance of Detention or Retention facilities within the City of Goodyear is usually the responsibility of the property owner or the Subdivision's Homeowners Association.

3.3.8 Summary of Drainage Design Guidelines

The following guidelines are based on recurring drainage and flooding problems observed in Goodyear related to specific design or construction practices:

A. Subdivisions

1. A subdivision should always have an approved subdivision-wide drainage plan. Drainage based on individual lots submitting separate grading plans as each lot is developed should be avoided.
2. Avoid design of a common drainage facility that requires maintenance by individual property owners. Put the drainage facility in a common Tract with the Homeowner's Association responsible for maintenance.
3. People have no awareness and/or incentive to perform the necessary maintenance unless they are directly and adversely affected.

B. Storm Drains

1. Avoid if at all possible the interception of an offsite natural wash with the intent of collecting it and putting it into a pipe or an underground storm sewer system.
2. Washes and even man-made channels carry a never ending supply of sediment and debris. It is almost impossible to collect and filter out this debris without a constant clogging and maintenance problem. If there is no alternative to the routing of an open channel into a piped system, water should be first routed into a sediment or debris basin. Periodic maintenance of the debris basin should be planned by the Homeowner's Association.

C. Culverts

1. Culverts should not be placed more than 0.5 feet below the natural wash invert, or the capacity must be reduced by the cross section area below this depth.
2. Culverts or homemade bridges for private driveways or walkways over washes or drainage channels whose source originates off-site or off-lot should generally be designed by a professional civil engineer/drainage designer.

3. For small private driveways or walkways, dip crossings or free span bridges that won't constrict the flow capacity of the channel, are recommended. Small drainage structures not designed with any hydrologic and hydraulic analysis may be OK for crossing channels originating onsite (on-lot). Homemade drainage structures can be disastrous for the homeowner, his neighbors, and adjacent streets if installed on larger washes originating offsite (off-lot) without the help of a professional, and shall be designed by a professional Civil Engineer.

D. Open Channels

1. Diversions of natural washes or changes in the channel's profile should be avoided whenever possible.
2. Do not permit encroachment into a drainage easement, channel, or its floodway.
3. If channel lining or landscaping material is used it must be inlaid or located below the design invert (bottom) of the channel. Do not place it on top of the designed finished grade of the channel cross section. The channel surface material (roughness coefficient) or cross sectional area shall not be changed without a plan revision and reapproval by the City.

This is a serious wide-spread construction and design oversight. Lining and landscaping material is commonly and incorrectly shown on plans and actually placed on top of the design channel bottom. This reduces and can eliminate a channel's conveyance capacity. This practice also makes it difficult for flow to enter such a channel, often causing ponding and backwater problems on streets and adjacent properties.

4. If only the channel banks are being lined, the lining material must extend down below the channel invert to below the anticipated scour depth.
5. Avoid designing turns in open channel conveyance systems sharper than 45 degrees, whenever possible. If curves or bends can't be avoided the run-up on the outside of curves must be calculated and incorporated into the channel design.

6. Lot lines should not extend out where the overlay or cross a drainage easement or wash. The wash area or drainage channel should be dedicated in a separate drainage easement Tract whenever possible. This will avoid “backyard” drainage channels, which can result in serious flooding problems.
 - a. Block walls or fences commonly separate lots. Channels that go under or through these walls commonly catch debris, clog, and block or divert flow. Homeowners will sometimes unknowingly and other times on purpose block off or plug these openings. There is no way for the City or a Homeowner’s Association to inspect, or maintain these openings. In addition, the size of many of these openings is never actually designed or analyzed. Backyards, pools, houses, and lots can be flooded; and walls knocked over and/or undetermined when these openings do not function properly.
 - b. Lot lines should end at the edge of the wash floodplain, or man-made channel, not in the middle or on the other side. Building envelopes are not recommended for delineating drainage easements. They can help but are too often misunderstood or ignored as a limit to construction of walls or structures.

7. **Drainage Easement**
Record all required drainage easements as early in the planning and development process as possible. Discontinuous drainage easements for channels are not permitted. Missing drainage easement segments must be dedicated as development takes place.

Table 3.3-1
Hydrology Design Criteria

Drainage Feature	Peak Frequencies			
	5 Year	10 Year	50 Year	100 Year
Street with Curb & Gutter	Runoff (the flow of water) on collector and local streets contained within street	Runoff (the flow of water) on arterial streets contained within street curbs. For major collector and all arterial streets one 12-foot dry lane must be maintained in each direction.	Runoff on arterial streets contained between the property lines. Runoff on collector and local streets contained between the buildings (front yard and street).	Runoff to be confined to road right of way or to drainage easements. Maximum depth for water (d_{max}) $d_{max} = 8$ inches above (low spot) the street. Major collector/arterial runoff below the finished floor of adjacent buildings.
Street with Storm Drain System	N/A	Pipes or roadway channels are added if the 10-year runoff exceeds street capacity as addressed above.	N/A	Storm drain systems are used if 100-year runoff inundates the building's first floor. Storm drain systems: catch basins, cruppers, etc. to be provided to remove water so as not to exceed $d_{max} = 8$.
Cross Road Culvert or Bridges for Local and Minor Collector Streets	N/A	N/A	Runoff to be conveyed by culvert or bridge under road with no flow overtopping the road.	Runoff to be conveyed by culvert and by flow over the road with maximum 6-inch flow depth over the road. Minimum Freeboard for Bridges 2.0 ft.
Cross Road Culvert or Bridges for Local and Minor Collector Streets	N/A	Runoff to be conveyed by culvert or bridge under road with no flow overtopping the road.	For a 25 year frequency storm runoff to be conveyed by culvert or bridge and by flow over the road with maximum 6 - inch flow depth over the road.	Maximum depth flow over road 12 inches.
Any street crossing a water course that provides the only access to residential areas	N/A	N/A	N/A	All lots and structures must be accessible by at least one route with the depth of flow no greater than one foot over the road during the 100 year run off event.
FEMA Floodplain Channel	N/A	N/A	N/A	100-year peak discharge.
Channel to Convey Offsite Flow Through Development	N/A	N/A	N/A	100-year peak discharge
Stormwater Storage	N/A	N/A	N/A	100-year 6 hour runoff for determining on-site storage volume.